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ABSTRACT

Humans have a large advantage over other life forms on earth in that they have been able to use their superior hand and brain power to invent ways to harness energy resources. The discussion in this booklet considers time, space, and spirit. Time refers to a sense of history; space refers to geography; and spirit refers to life and thought. Several chapters on the history and concepts of the ways humans use energy, a time line related to the concepts, a map of the important geography related to these concepts, a glossary of important terms, and a list of several study suggestions are included. (CW)

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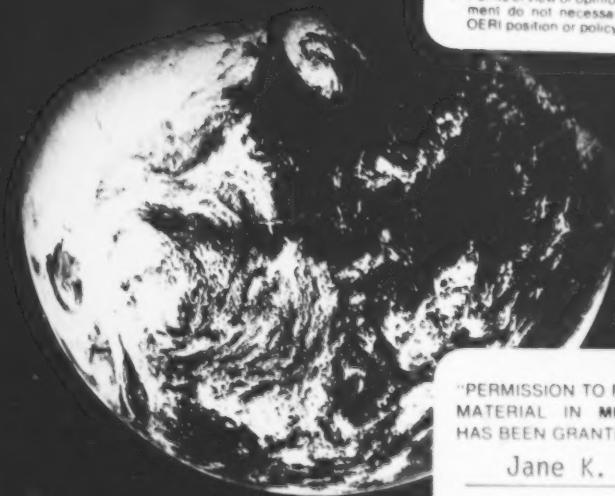
Energy and Society

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A HAWKHILL LEARNING POWER BOOK

SE 051 123

TIME, SPACE AND SPIRIT

KEYS TO SCIENTIFIC LITERACY

To the student,

This short book will help you understand our modern world. It has changed a lot since your parents were born. Even more since you were born. And it will change still more—much more—in your lifetime.

What is behind most of these big changes? Two things. Science and technology.

What can you do about it? The first step is to understand more about science and technology and how they connect with our world. Especially the ever-growing world of free democratic societies. One way to do this—the way this book follows—is to look at the world from three angles: *Time*, *Space* and *Spirit*.

Time means history. You can learn how science and technology have worked in the past and are working today.

Space means geography. You can learn where important things happened in the past and are happening today.

Spirit means life. The life of the mind. You can learn the key words, concepts and ideas that power science and technology (and society) today.

This book teaches about science, technology and society from all three of these angles—*Time*, *Space* and *Spirit*.

Read on.

This book belongs to:

Energy and Society

Bill Stonebarger
Illustrations by Lin Haley
and Carolyn Pieper

Hawkhill Associates
Madison, Wisconsin



This book is one of a series of sixteen Learning Power Books in the *Time, Space and Spirit—Keys to Scientific Literacy* series. It is designed to accompany the video program of the same name.

The *Time, Space and Spirit—Keys to Scientific Literacy* series was written and produced with consultation from the History of Science Department at the University of Wisconsin-Madison.

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Part 1: A Short History of Energy and Society



Homo sapiens in East Africa

Three million years ago the first human beings walked upright on this amazing earth. The first humans, we think, walked in East Africa. They shared the earth with a great variety of animals.

Many of these other animals were bigger, stronger, faster and more spectacularly good looking. Then, as now, there was a lot of competition for food, for living space, for a place in the sun.

a better hand and a better brain

In this often fierce competition the first humans had two things going for them. A better hand, and a better brain. Three million years later many of the same animals are still in East Africa, just as big, strong, fast and spectacularly good looking. The one animal with the better hand and the better brain is there, here and everywhere.

How did we get from there and then to here and now?

energy of hand and brain

If you are looking for the shortest best answer, I could sum it up in one word, energy. Energy understood in two senses, hand and brain, muscle and mind.

learning how to learn

Humans, that is, have used their superior hand and brain power to invent ways to harness energy



resources far bigger, stronger and faster than plant tissue and animal muscle. And even more important, humans have learned how to learn. Have learned how to become ever more productive. Have learned how to create a more human world for themselves. Let's take a

look at the details.

the Masai people

Recently I visited East Africa. I saw many magnificent animals on the plains of Serengeti and the volcanic soil of the Great Rift Valley. And I met some impressive people who lived there. People called Masai. The Masai live in East Africa in very small villages, much as their ancestors did thousands of years ago.



**wealth is
cattle**

For the Masai then and now, wealth (and energy) means cattle. The Masai depend on their cattle for food, shelter, transportation—for just about all the energy of living. One exception is the energy the Masai get from burning small bundles of wood in their cooking.

**energy from
wood and
muscles**

To get the wood for cooking, the Masai women must cut it and carry it—often from long distances. The energy they use for this cutting and carrying is supplied by the women's muscles, which in



turn get energy from the cattle's milk and blood. In rough outline this is the way all early people all over the world—including all of our own ancestors—got their life energy and lived. Energy, that is, came from two sources, plants and animals.

When a people must live with only the energy from the plants and animals around them, we call it a low-energy society.

**a low-energy
society**

Living in a low-energy society is not all bad. The Masai, and most other low-energy societies of the past and present, know the meaning of love. Love for wives and husbands, children and friends. They often have a good deal of leisure. They have a religion and a sense of belonging.

But living in a low-energy society also means living in a society where most people eat only what they can grow, catch or gather; a society where most people never travel more than a few miles from where they are born; a society where most people cannot read or write; a society where most people live in almost daily fear of wild animals and often of wilder and fiercer neighbors; a society where most people are hungry much of the

time and sometimes starving; a society where most people must live with sickness and disease much of the time, and where few people live beyond the age of thirty-five.

How, especially in America, Europe and Japan, did we get from a society of low energy to a society of high energy?

high-energy society

A society where only two or three percent of the people are farmers, herders or fishermen so that most people eat only what other people grow, herd or catch for them. A society where most people travel many thousands of miles in their lifetimes; a society where most people can read and write; a society where most people (unfortunately not all) seldom experience violence except vicariously on TV or in the movies; a society where most people are healthy most of the time and where most people live to be older than seventy years. In short, a society of high energy.



how we got there

How did we get from there to here? It wasn't easy. Here are a few of the most important steps on that road.

the first step

The very first step on the road to high-energy societies came when humans learned to grow food in gardens and fields, and to tame and husband animals.



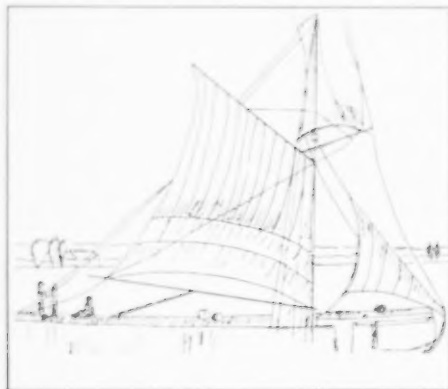
In these ways the first human societies could now have a larger and more reliable supply of food energy and animal muscle power. Still not very large, but larger and more reliable than a life of hunting, fishing and gathering wild foods could provide.

agricultural revolution

It was this agricultural revolution that led to the growth of the world's first civilizations in Africa, China, India, Egypt, Greece and Central and South America. Energywise the Masai people, and most of the present underdeveloped world are still living mostly in agriculturally based low energy civilizations.

sailing ships

Relatively small, but important, increases in energy came to agricultural civilizations a few thousand years ago when some humans learned to use the energy of the wind and of flowing water to



serve their own needs.

Instead of walking a few miles, or riding a horse a few tens or hundreds of miles, a few sailors could now travel thousands of miles using the power of the wind and water.

These new sailing ships could carry heavy loads quite easily for thousands of miles, allowing them to trade goods with

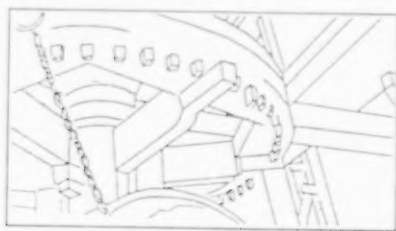
other people at great distances from them. Each could then supply what the other lacked, and each could profit.

energy from slaves

Another way, unfortunately, that many, if not most, agricultural civilizations of the past got more energy for themselves and their families and friends was by making slaves of other families and non-friends. The use of wind and water was like getting more slaves to work for you, but these were slaves you didn't have to conquer, guard and feed.

windmills and waterwheels

Later some civilizations learned to get energy in another way. They invented and built unusual and ingenious machines that could use the power



of the wind or of falling water to do useful work. Work like pumping water, grinding grain into flour, sawing trees into boards. In this way still more nonhuman slaves were available. We don't know the names of

the particular mechanics, artisans, scientists and philosophers who invented these new ways of getting and using energy. We do know we owe them a great deal.

the most important invention

And we have forgotten some of the most important pioneers of all. The inventors whose invention came before all the rest and whose invention would lead in our day and age to energy sources undreamed of in past ages. I am talking about fire.

In early low-energy societies fire was used for cooking food, for defense against wild animals, for warmth in cold climates, for firing pottery and for getting useful metals like copper, lead and iron from otherwise useless rocks.

the Industrial Revolution

A little more than two hundred years ago—about the time of our American Revolution—fire began to be used in a far more dramatic and revolutionary way. Fire became the energy source for what is called the Industrial Revolution. This revolution is still going on all over the world, changing low-energy societies into high-energy societies. Let's look at some details of this momentous change, by far the most important one since the agricultural revolution thousands of years before.



democracy and capitalism

Historians do not agree on what caused what. The growing influence of new ideas like free trade, capitalism and democratic political systems probably played the most important roles.

began in England

These ideas were most influential in Western Europe, especially in England. In fact, most historians think the Industrial Revolution began in England in the late eighteenth century. During the nineteenth century the revolution spread rapidly throughout Europe and North America. In our own twentieth century it is rapidly changing just about every society on earth.

the bridge at Coalbrookdale

Some trace the beginnings of the Industrial Revolution to a small city in central England named

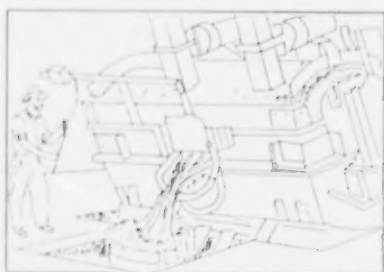
Coalbrookdale. The same year as our own Declaration of Independence, 1776, the English parliament put up the money to build the first iron bridge in the world in Coalbrookdale. The bridge was completed five years later and still



stands today. In the late eighteenth and early nineteenth century engineers, iron-makers, industrial spies and artists from all over Europe flocked into Coalbrookdale to see how they did it. So far as energy goes, the most important change from thousands of years of iron making was a new method at Coalbrookdale that used coal instead of wood as the source of energy. By using this new more highly concentrated source of energy, whole new possibilities opened up and were soon exploited.

new methods in iron making

Instead of only using high-priced charcoal-smelted iron for special purposes like swords, armor, locks, knives, iron



bolts, chains and pots and pans, Coalbrookdale quickly became a leader in using the now more plentiful iron to forge wagon wheels, to make the first iron rails and wheels for the newly invented rail-

roads and, most important of all, to make cylinders for the newly invented steam engines.

powered by coal

As far as our story goes, the important thing to remember is the sudden leap forward in brute energy and power that human societies could now count on to serve human purposes. The basic energy for this leap, remember, was provided almost completely by a black rock dug out of the ground, often at great human peril. That all-important black rock was coal.

fossil fuels

Coal is what we call today a fossil fuel. It got its highly concentrated energy by storing the sunlight of millions of years ago. That millions-of-years-ago sunlight was caught by green plants in ancient swamps. Some of these ancient plants

died and piled up and slowly decayed into what we now find as veins of coal. Sometimes these veins of coal are near the surface of the earth today, and sometimes they are deep underground. Coal had been known to many ancient societies, but it was used only sparingly. In the nineteenth century, however, this stored sunlight became the power source to change the world.

the steam engine



To use this energy, the most powerful machine was the steam engine. One thing led to another, and again no one can be sure what caused what. (The steam engine, for instance, was invented to pump water from deep coal mines!) Soon the steam engine was improved and became a power source for railroad locomotives, steamships, factories, mills and mines. And by the end of the nineteenth century, steam engines were being used to produce the most versatile kind of energy of all, the newly invented electricity.

the Industrial Revolution changes ways of life

Coal and iron made the nineteenth century a century of rapid population growth, impressive new cities, ostentatious new wealth ... and urban poverty, industrial pollution and large-scale wars the likes of which the world had never before seen. Poverty, pollution and wars were nothing new, it was true. For thousands of years, ninety-nine percent of the people who lived in low-energy



agricultural societies had lived always and everywhere with poverty, disease, wars and pollution. As Thomas Hobbes, a seventeenth century philosopher in England, once put it, "the life of man everywhere is nasty, brutish and short."

the few who escaped poverty

Even the elite few who escaped poverty—the kings and queens, the bishops and nobles—could not escape disease, wars and pollution. For even the wealthiest human beings the average life span was still less than thirty years.

big changes

In the nineteenth century Industrial Revolution, however, everything suddenly went topsy-turvy. On the one hand the sudden new increases in energy and wealth meant that many more people could live richer lives. They could now travel more, eat better, read and write, and had many more choices about what they could do with their lives. The average life span increased to over forty-five years.

the good and the bad

On the other hand, the new factories and cities, the new smokestacks and urban crowding, the new railroads and education and literacy made



old problems seem even worse. They made them seem this way because now people began to sense that the problems were solvable. One did not have to be poor. One did not have to have diseases. One did not have to put up with wars and inequality and pollution.

hope and anger

And that sense of hope (and anger) has continued and increased throughout the twentieth century.

The hope and anger has spread from Europe and North America into Asia, South America, Africa and Oceania.

more energy sources

On the physical level, the energy sources to power the Industrial Revolution have vastly increased. So too has the pace of learning and invention. And finally, so too has the pace of social change, as almost everywhere people are becoming aware of and demanding more democratic political and economic institutions. As well as more wealth, security and energy.

oil and gas come on line

Coal has continued to be an important energy source for the twentieth century. However, beginning about the turn of this century



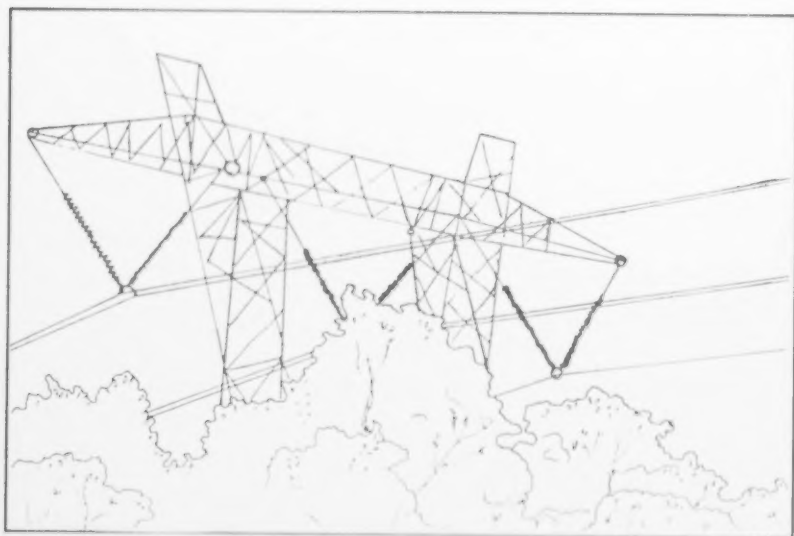
two other fossil fuels, oil and natural gas, have come to play equally important parts. And in the final decades of this century still newer sources of energy are coming onto the scene. Energy sources like nuclear power, new forms of solar power, geothermal power, tidal power and biomass power.

contrasts today between developed and underdeveloped world

All of these energy sources today, old and new, have given the average person in America, Europe and Japan the equivalent of over one hundred human slaves apiece, working just for him or her, while the average person in many parts of Asia, Africa and South America must still do with the energy generated by human and animal muscles.

But the times they are changing.

Part 2: Energy for Today and Tomorrow



energy is everywhere

Energy is everywhere. Energy is things happening. Energy is the power of life.

The universe has no more energy now than it had a million years ago. And a million years from now there will still be the same amount of energy we have today. For energy cannot be created or destroyed. It can only be changed from one form into another.

changing from one form to another

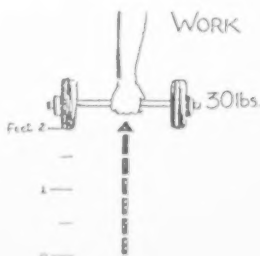
It is these changes in energy from one form into another that make all the difference. And all things considered, though energy changes in nature are far more powerful, the energy changes brought about by the human hand and mind are the most interesting.

Energy today and tomorrow is a big subject. To help sort out facts from opinions, headlines from reality, let's take a look at energy from three dif-

ferent points of view—science, technology and society.

the ability to do work

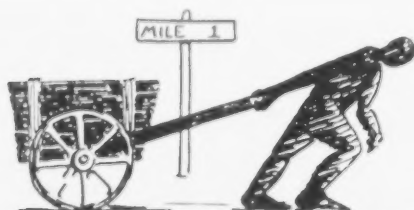
First we'll look at the scientific side of energy. Energy, to the scientist, is the ability to do work. Work is defined as a force moving through a distance.



foot-pounds

It is useful to express this mathematically. If you lift a thirty-pound weight a distance of two feet, a scientist would say you did 30 times 2, or 60 foot-pounds of work. If you pull a wagon with a force of 30 pounds through a distance of one mile (5,280 feet) the scientist would say you did 30 times 5,280, or 158,400 foot-pounds of work.

$$30 \text{ lbs.} \times 2 \text{ ft.} = 60 \text{ foot-pounds of Work}$$



$$5,280 \text{ ft.} \times 30 \text{ lbs.} = 158,400 \text{ ft. lbs. of Work}$$

where did the energy come from?

The energy you used to pull the wagon came from the calories in the food you ate for lunch. Where did the food get the energy? From the sunlight that powered the plants that were made into food in the process called photosynthesis. (If you had meat or dairy products for lunch, the energy still came from the sun by way of the plants, since that is where the cows got their energy.)

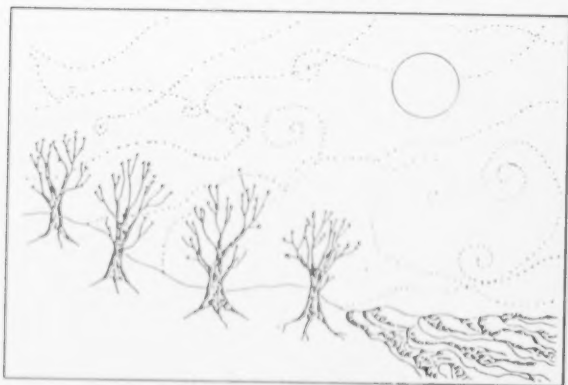
energy not destroyed

That sunlight-to-plants-to-human energy is not destroyed when you "used it up" in your work. In

energy as random heat

this use the energy was changed into other forms. First into mechanical, and finally into heat energy. Foot-pound for foot-pound for foot-pound.

Even though there is the same amount of energy before your work as after you finish, there is an important difference. After the work is done, the energy is no longer in a useful form. There is no way you can now capture it and turn it back into useful work. Instead, the energy is now in the form of random heat energy that will soon radiate away from earth back into space. Random heat energy is useful only for warming the universe.



laws of ther- modynamics

Unfortunately, all energy changes on earth end up this way as random heat. Scientists call this one-way flow of energy the second law of thermodynamics. (The first law of thermodynamics is that energy cannot be created or destroyed.)

technology to change energy from one form to another

We can change one form of energy into another by the use of technology. Nature's technology or human-created technology. Both follow the same scientific laws. One of nature's most important inventions is the green leaf. Green leaves can change solar energy into the chemical energy of food. A muscle cell can change the chemical energy of food into the mechanical energy of motion. A brain cell can change food energy into feel-

ings and thought. Human beings have invented many new ways for changing one energy form into another. Whether we use nature's technology or human technology, in any change of energy we are very interested in making that change as *efficient* as possible.

doing more with less

In every energy change some of the energy is lost. As humans we want to make that loss as small as possible. This means we want to have machines as efficient as possible. We want to squeeze as much work out of them as we can, putting the least amount of work into them. We want to do more with less.

efficiency

The efficiency of a machine can be calculated. It is always the amount of work you get out divided by the amount of work you put in. Since you can never get as much work out as you put in, this means that the efficiency of any machine is always less than one hundred percent.

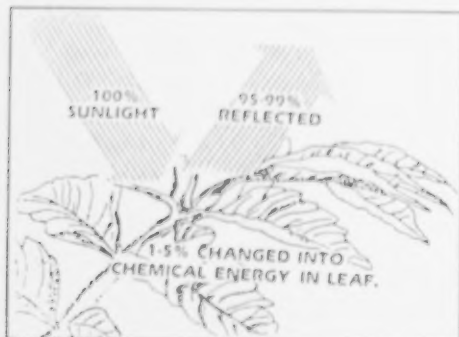
$$\text{efficiency} = \frac{\text{work out}}{\text{work in}}$$

green leaves as energy converters

The most important energy conversion machines on earth are green leaves. Typically green leaves can convert one to five percent of the sun's energy

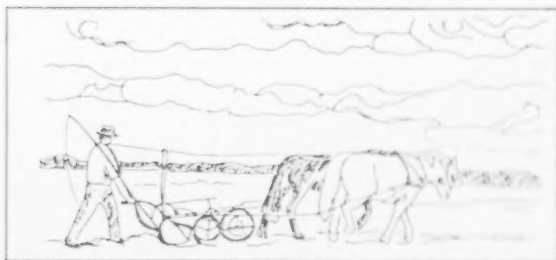
into a stored form of chemical energy in the plant leaf, stem, root, seed or fruit.

Food is the name we give to some of the chemical storehouses of energy that the plant produced.



animals as energy converters

Animals who eat this plant food are a bit more efficient. They can convert about ten percent of the food energy into animal activities like movement, sight, hearing, speech, feelings and thought. The other ninety percent is lost to random heat energy (just as was the ninety-five to ninety-nine percent of the solar energy received by the green leaves).



light bulbs

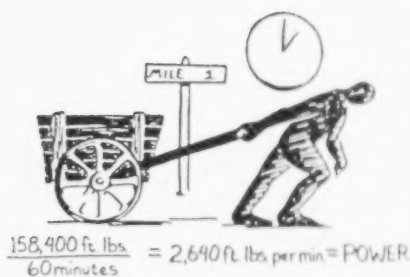
Incandescent light bulbs are another kind of energy-converting machine. They are about eight percent efficient in converting electrical energy into light energy. The other ninety-two percent of the electricity they use goes into making heat. Fluorescent bulbs are more than twice as efficient as incandescent ones.

higher efficiency machines

Automobile engines have efficiencies around twenty-five percent. Steam-electric power plants get thirty-eight percent efficiency and more. Large electric motors and generators today get over ninety percent efficiency. And the efficiency of all these machines is being improved dramatically every day.

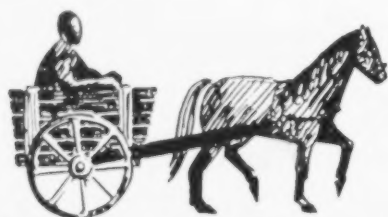
power

Another unit important in the technology of energy is power. Power takes into account how fast the work is done. If it took you one hour to pull a wagon one mile, the scientist would say you had a power of 158,400 foot-pounds per hour. Or dividing by the sixty minutes in one hour, you have a power rating of 2,640 foot-pounds per minute. A horse could do the same amount of work faster.



Or could do more work in the same amount of time. A horse has more power than a person. James Watt, one of the pioneer inventors of the steam engine took some measurements and found that a strong horse could do about 33,000 foot-

pounds of work a minute—over ten times as much as a human being could do. He used this figure-- 33,000 foot-pounds per minute—and called it one horsepower.



33,000 ft. lbs. per minute = 1 Horse Power

horsepower and business

Watt made up the horsepower unit to help in selling his new steam engines. He pointed out that his new machines were smaller than a horse, used cheap coal instead of expensive hay for fuel, never got tired and could do as much work as ten, twenty or even thirty horses. His business was a great success.

watts and kilowatts

Today we still use horsepower as a unit of power, especially for steam engines and internal combustion engines. For most other purposes, however, scientists use another unit of power, the watt (named after James Watt). It takes 745 watts to make one horsepower. Since a watt is usually too small a unit to be practical, we usually use kilowatt (one thousand watts) as the unit of measure for power today.

power comparisons

To see how our power has increased over the ages note these figures: the human body can generate about one hundred watts of power; a horse can manage five hundred watts; a steam engine can generate two million watts; a gasoline engine ten million watts; a steam turbine one billion watts; and a rocket sixteen billion watts.

Let's put these figures in another way. A way that will lead to the final of our energy points of view—that of society, that controversial arena where values play as big a part as facts.

power and society

Each person living in a hunting-gathering society can command about two hundred and fifty watts of power. A person living in an agricultural society can command about six hundred watts. A person living in a modern industrial society like the United States can command over twelve thousand watts. Tables below summarize these and other typical power outputs and efficiencies.

Typical efficiencies:		Power outputs (In watts):	
green leaves	1-5%	human body	100
incandescent bulbs	8%	ox	250
people & animals	10%	horse	500
solar voltaic cells	13%	windmill	15,000
automobile engines	25%	waterwheel	1,000,000
small electrical motors	29%	steam engine	2,000,000
smelting of steel	32%	gasoline engine	10,000,000
steam-electric generators	38%	steam turbine	1,000,000,000
hydrogen fuel cells	60%	rocket	16,000,000,000
storage batteries	70%		
gas furnaces	75%	(can command)	(per person)
large steam boilers	88%	hunting/gathering	100-250
dry cells	92%	agricultural	600-1,300
large electrical generators	99%	industrial (1900)	4,000
		modern industrial	12,000

**there is no
free lunch**

All of these watts—all of these nonhuman slaves you might say—that make our high-energy society so different from low-energy societies of the past and present do not come without costs. As the saying goes, "there is no free lunch."

**energy from
fossil fuels**

For one thing, most of the energy needed to make these watts of power today comes from the stored energy of fossil fuels—coal, oil and gas.

**changing the
climate?**

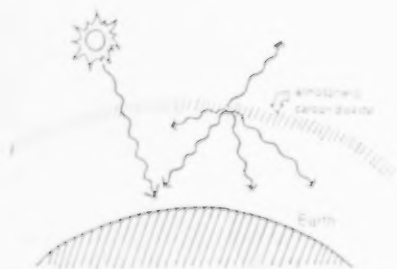
Amory Lovins, research director at the Rocky Mountain Institute, explains the problems this way. "We don't produce gas and coal. We dig them up and burn them. They were produced a long time ago. We don't know how to do that. Once we use them up, they're gone. There's an awful lot of fossil fuel in the world but we're starting to realize we can't burn it all. Especially we can't burn the bulk of it, which is the coal, for very long without changing the earth's climate.

"Whenever you burn, that carbon that's been locked up in the ground for a long time becomes carbon dioxide in the air. It absorbs heat. You get global warming. If you don't like it, in a while you can probably row up to the Capitol steps and complain about it."

**greenhouse
effect**

Lovins is talking about what is called the greenhouse effect. There is dispute about how long it

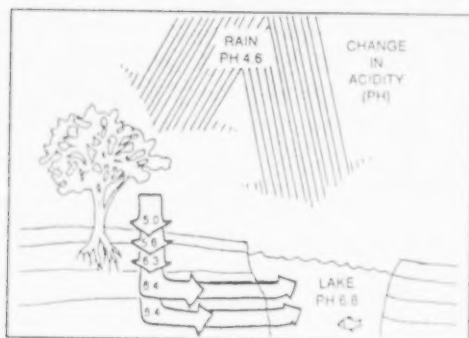
will take or how drastic its effects will be, but scientists generally agree that the more carbon dioxide we put into the air from burning fossils fuels, the more likely it is that the earth will become warmer. And probably within our life-



time. As the earth becomes warmer, the giant ice sheets at the North and South Poles will begin to melt. This will cause the ocean levels to rise. Coastal cities like New York, Los Angeles and even Washington D.C. could find themselves under water!

acid rain

Another problem that comes from too much burning of fossil fuels is called acid rain. Sulfur and



nitrogen oxides leave the smoke stacks of the power plant, combine with rain drops in the clouds and form an acid solution that can harm lakes, forests and farms hundreds, or even thousands, of miles away.

change energy sources and improve efficiency

One way to diminish or prevent the greenhouse effect and acid rain would be to change energy sources. A second way would be to use what energy sources we have much more efficiently. In the second case we would do just as much work (or more) but use less energy input. Hence there would be less pollution as well.

return to a low-energy society?

A third possibility would be to renounce high-energy society and go back to a simpler low-energy way of living. Not many would choose this way if it can be avoided, since it would also mean a drastic reduction in population and living standards. The people who know this low-energy way the best—those who now live in the underdeveloped world of Asia, Africa and South America—are near unanimous in wishing to move to a high-energy society. To be richer rather than poorer. To have more choices rather than fewer. To

three major issues in energy and society

have a more human society rather than a survival one. And the sooner the better.

So the third of our energy points of view, society, boils down to three major issues:

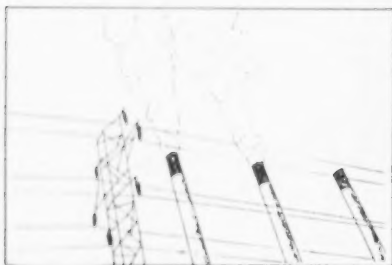
- 1) How best to change over from a fossil fuel to a nonfossil fuel based system. Ideally this would be a renewable energy source—that is, one that nature keeps replenishing as fast as we "use it up."
- (2) How best to use energy more efficiently no matter what the energy source. How to do more with less.
- (3) How to help the entire world change over to a high-energy, more human society, with the least amount of harmful side-effects.

On all three of these issues there are vast differences of opinion among the experts as well as ordinary citizens. How we answer one question has a great deal to do with how we answer the other questions.

how to answer questions in a democracy

These questions, and the relationships between them, are not so complicated, however, that the ordinary citizen cannot understand them or choose intelligently among possible answers. All it takes is a little study, thought and confidence.

Refer to the bibliography and to the study guide questions of this book. Read what various experts say. Hold a class debate. And then make up your own mind where you stand. In a democratic society like ours, how we as citizens make the choices will make all the difference.



TIME ...

To understand the world of today it helps to know something about the world of yesterday. Kings and queens, wars and famines, presidents and paupers have all played a part. But more important than any of these in changing the past world into the world of today has been science and technology. The time line below will help you place important events and people in historical time.

EVENTS IN WORLD HISTORY

600-300 B.C.
Golden Age of
Greece

Birth of Christ

200 B.C. to
A.D. 450
Roman Empire

500-1300
The Middle Ages

1400-1700
Renaissance

1776
Declaration of
Independence

1800-today
Industrial Revolution

EVENTS IN SCIENCE & TECHNOLOGY

(Agricultural Revolution
began approximately 8000
B.C. in Africa, Asia, Europe,
North & South America.)

600 B.C. to
A.D. 1800
Sailing ships and other wind
and water energy machines

500-1300
advances
in energy technology,
including horse collars,
windmills & waterwheels

1400-1700
modern science begins
with Galileo, Newton
and others

1800-present
Industrial Revolution

500
B.C.

A.D. 1

500

1000

1500

2000

500
B.C.

A.D. 1

500

1000

1500

2000

EVENTS IN WORLD HISTORY

1776
American Revolution

1800

1861-65
Civil War

1850

1914-18
World War I

1900

1929-38
worldwide economic
depression

1939-45
World War II

1950

1950-52
Korean War

1966-73
Vietnam War

2000

EVENTS IN SCIENCE & TECHNOLOGY

1774
James Watt invents a
steam engine;
new methods of iron
making in England

1800

1830
Industrial Revolution
expands rapidly in England,
Germany and Europe

mid-1800s
Faraday, Maxwell & others
make fundamental
discoveries in electricity
(U.S. life-expectancy, 40
years)

1850

1880
Edison's first electric light

1900

1908
Ford brings out Model T
(U.S. life-expectancy, 50
years)

1920s
Oil and gas replace coal as
#1 energy source

1950

1941
first working nuclear
reactor

1960
photovoltaic cells cost
\$100 per kwh

1990
photovoltaic cells cost 13
cents per kwh
(U.S. life-expectancy, 75
years)

2000

SPACE ...

There is a saying, "If you don't know where you are going, any road will get you there." One of the important parts of knowing where you are going is a knowledge of geography. The map below will help you to locate the important events and people discussed in this book.



1. East Africa

Where *Homo sapiens* first walked this earth. Today this area includes the modern countries of Ethiopia, Kenya, Tanzania and Uganda.

2. Ionian Greece

Site of the first city-states to encourage speculation in natural science and philosophy. Now a part of modern Turkey.

3. Industrial Revolution

Areas where industrial revolution began in late eighteenth and early nineteenth centuries.

* Agricultural Revolution

Areas of early agricultural civilizations where human technology first developed.



1. England

Where the Industrial Revolution began in the late eighteenth and early nineteenth century. Spread throughout Europe and North America in the nineteenth century.

2. Chicago, Illinois

Site of first working nuclear reactor in 1942. By 1989 nuclear power plants have been built and operated in all the major countries of the world and now provide over ten percent of world's electricity (over thirty percent in Europe).



Fossil fuel deposits

Areas with major deposits of coal, oil or gas in 1980. Size of the symbols gives rough idea of size of fossil fuel reserves.



High-energy in 1990.

Areas with high-energy industrial societies in 1990. (More than fifty percent of population works in non-agricultural occupations with per capita annual incomes of over \$2500 U.S. dollars. Per capita income in some oil-exporting countries like Saudi Arabia and Libya is over \$2500 but their societies are still primarily preindustrial.)

SPIRIT ...

Time and space are meaningless without spirit. Spirit is the part in each of us that understands. The part that sees connections between words and things—connections that surprise and make sense. Study the key words, concepts and ideas below so that you can understand how time, space and spirit worked in the past—and are working today.

- acid rain** Rain that has sulfur and nitrogen oxides dissolved in it. Known to damage lakes and forest ecosystems. (p. 20)
- agricultural revolution** A time three to four thousand years ago when many societies learned how to grow crops and husband animals. The beginning of ancient civilizations. (p. 5-6)
- carbon** A chemical element that is present in all living things as well as the major part of fossil fuels, coal, oil and gas. (p. 19)
- carbon dioxide** When carbon combines with oxygen you get carbon dioxide. Plants use it to make food. Too much in the atmosphere can cause the "greenhouse effect," warming the earth. (p. 19)
- coal** A black rock found in many deposits throughout the world. The basic energy source for the industrial revolution and still important today. (p. 8-9, 11)
- democracy** A form of political organization that values individuality, constitutional rights and equality of opportunity. Along with capitalism, important in providing a base for scientific and industrial revolutions of nineteenth century in Europe and North America. (p.11, 19-20)
- efficiency** In scientific meaning, the ratio of the work you get out of a machine divided by the work you put into the machine. (p. 15-18)

energy	The ability to do work.
foot-pounds	A measure of the amount of work done. The force in pounds times the distance in feet. (p. 13-14)
fossil fuels	The remains of ancient prehistoric plants and animals, now found as coal, oil and gas. Used for energy and as a raw material for many chemicals in modern societies. (p. 8-9, 11)
greenhouse effect	When the percentage of certain gases, especially carbon dioxide, increases in the atmosphere, causing a warming trend. (p. 19-20)
horsepower	A unit of power invented by James Watt. It is equal to 33,000 foot-pounds a minute. (p. 17)
Industrial Revolution	The very great changes in human life brought about by capitalism, democracy and advances in science and technology in the nineteenth century. Began in England but quickly spread throughout Europe and North America, and is now rapidly spreading throughout the world. (p. 7-11)
kilowatt	A unit of power equal to one thousand watts. (p. 17-18)
laws of thermodynamics	The first law of thermodynamics states that energy cannot be created or destroyed. The second law says that energy is always lost (made unavailable) in any energy conversion. (p. 14)
nuclear energy	Energy from the breaking apart (or coming together) of the nuclei of atoms. (p. 11)
photosynthesis	The process used by green plants to convert sunlight into a stored chemical energy in food. (p. 13)
power	The amount of work done divided by the time it takes to it. Common units are horsepower and kilowatt. (p. 16-17)

renewable energy	Energy sources that are regenerated by natural processes, rather than "used up" as in the fossil fuels. (p. 11, 21)
solar energy	Energy from sunlight. It can take many forms, such as solar heat panels, solar voltaic cells, photosynthesis, biomass, etc. (p. 11, 14-18)
solar voltaic cells	Thin cells made primarily of silicon that can directly convert sunlight into electricity. (p. 29)
technology	The use of skill and knowledge to invent, produce and operate useful machines and devices for the benefit of human life. (p. 6, 14-15)
Watt, James	An English inventor given credit for inventing the steam engine in 1815. (p. 17)
watt	A unit of power. There are 745 watts to a horsepower. (p. 17-18)

In addition to the above, *Energy and Society* also teaches about other important people, places, things and ideas. Often you can figure out the meaning of a new term by seeing how it is used in context. Make sure you know the meaning of the following (for help, check the pages listed in this Learning Power Book, as well as your dictionary and encyclopedia):

Africa (p. 1, 5); biomass (p. 11); capitalism (p. 7); charcoal (p. 8); chemical energy (p. 14-16); China (p. 5); Egypt (p. 5); geothermal (p. 11); Great Rift Valley (p. 3); Greece (p. 9); Hobbes, Thomas (p. 10); hunting-gathering society (p. 18); life-span (p. 4-5, 10); Masai (p. 2-3); pollution (p. 19-20); Serengeti plains (p. 3); steam engine (p. 17-18); underdeveloped world (p. 20-21).

STUDY SUGGESTIONS ...

1. Amory Lovins says "I don't use the term *energy conservation* because to about a third of Americans it means privation, discomfort, curtailment, doing without. What I'm talking about is doing more with less by using the energy in a smarter way that saves money." Investigate the differences between stressing *conservation* and stressing *efficiency*. Discuss and debate in class.

2. Everyone agrees that eventually we will run out of fossil fuels as a source of energy on earth. There is much dispute, however, as to whether we will run out in a few decades, a few centuries or a few thousand years from now. Compare the facts and the opinions on this question in two books in the bibliography, *Global 2000 Report to the President* and *The Resourceful Earth, A Response to Global 2000*.

3. In the early 1970s solar voltaic cells cost approximately \$100 a kwh (kilowatt-hour). Ten years later the cost had come down to about \$10 a kwh. The most recent breakthrough has brought the cost down to about thirteen cents a kwh (average cost of electricity from a power plant in the U.S. today is about seven cents a kwh). Investigate and debate the potential of solar voltaic cells for answering all three of our major issues: (1) how best to change from a fossil fuel to a renewable energy source; (2) how best to use energy more efficiently; (3) how to help the entire world change over to a high-energy society with the least amount of harmful side-effects.

4. The future of nuclear power is one of the most controversial areas of energy and society debates today. No new nuclear power plants have been ordered in the United States for over ten years. Nuclear plants are, however, being constructed in many other countries including France, Japan and the USSR. Some physicists and nuclear engineers point out that new designs for fission plants make accidents extremely unlikely and that nuclear energy does not pollute the atmosphere with gases that cause acid rain and the greenhouse effect. Investigate and speculate on what the future of nuclear power will be in this country and in the world.

5. Question four focuses on nuclear *fission* energy. If and when physicists solve the problems of producing commercial energy by nuclear *fusion*, it may change the energy and society equation again. Investigate and discuss the future of nuclear fusion energy.

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Special note: Some of the most authoritative reports and publications on current energy issues can be found in the free quarterly newsletter published by Resources for the Future, 1755 Massachusetts Ave. NW, Washington, DC 20036.

Another source of useful information on all energy issues, especially those of energy efficiency is the Rocky Mountain Institute, 1739 Snowmass Creek Road, Snowmass, CO 81654.

For current information on energy in education write National Science Teachers Association, 1742 Connecticut Ave. NW, Washington, DC 20009.

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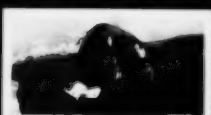
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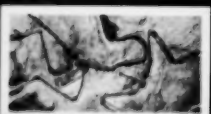
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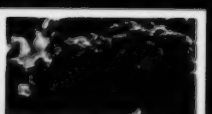
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